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TOPICS SUITABLE FOR THE DEVELOPMENT OF PRINCIPLES OF CHEMISTRY AS FOUND FROM AN ANALYSIS OF FOUR HIGH SCHOOL TEXTBOOKS

by

John James Ryan
(B.S., Boston College, 1940)

A thesis submitted to the School of Education,
Boston University, in partial fulfillment of the
requirements for the Degree of Master of Education

Boston, Massachusetts
April, 1948

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CHAPTER I

SURVEY OF RELATED LITERATURE

INTRODUCTION

In the last sixteen years, since the publication of the Thirty-first Yearbook of the National Society for the Study of Education,[1] increasing emphasis has been placed upon the understanding of major generalizations of science and the concomitant scientific attitudes as important objectives of science teaching. Numerous research studies which will be referred to in this chapter, conclusively prove that the functional understanding of principles or a working knowledge of the major generalizations should be the basis of the organization of science instructional materials.

The functional understanding, for example, of such a principle as "elements are made up of small particles of matter called atoms which are alike in the same element but different in different elements", has a far-reaching effect greatly exceeding its value as a topic taken up in secondary school science courses.

Two comprehensive statements of the purposes of science are those of the Thirty-first Yearbook in 1932 and the Thayer Commission on Secondary School Curriculum of the Progressive Education Association.[2] The report of the Thirty-first Yearbook stressed that all science education be organized along certain broad generalizations or principles. It gave a

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[1]A Program for Teaching Science, Thirty-first Yearbook of the National Society for the Study of Education, Part I, Bloomington, Illinois: Public School Publishing Company, 1932.

[2]Progressive Education Association, Commission on Secondary School Curriculum, Science in General Education. New York: D. Appleton-Century Co., 1938

list of principles which it recognized as incomplete but which would serve as a guide for future researches. The Thayer Commission asked that science teaching be oriented to the broad areas of living characterized as (1) personal living, (2) immediate personal social relationships, (3) social-civic relationships, and (4) economic relationships. A fifth was added, the ability to use reflective thinking.

The Thayer Commission Report included a discussion of the scientific method as an objective of science teaching. Later reports stressed such matters as safety, consumer, and conservation education.[3]

If the classroom teacher is to have confidence in any of the newer textbooks, he must be certain that they are organized according to a plan ensuring the functional understanding of the "Big ideas" of science. The importance of a study of such principles is evident when we consider the relation of success in this undertaking with the realization of the larger goals as given by the Forty-Sixth Yearbook of the National Society for the Study of Education[4] in its chapter on objectives:

> "Science is today on a plane of high significance and importance. It is no longer, if indeed it ever was, a mysterious and occult hocus pocus to be known to only a selected few. It touches, influences, and molds the lives of every living thing. Science teachers have a great opportunity and responsibility to make a large contribution to the welfare and advancement of humanity. The intellectual aspects of this responsibility are at least co-equal in importance with the material. Science is a great social force as well as a method of investigation. The understanding and acceptance of these facts and this point of view, and their implementation in practice, will, more than anything else, make science teaching what it can be and should be."

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[3]American Council of Science Teachers, National Committee On Science Teaching, Teaching For Better Living, Washington: National Education Association, 1942.

[4]Science Education in American Schools, Forty-Sixth Yearbook, Part I, National Society for the Study of Education, Bloomington, Illinois; Public School Publishing Company, 1947

The formulation of principles at different levels of complexity is of tremendous importance. A great deal of research has been done on this problem and many worthwhile principles have been developed. In this research I have chosen the principles for the physical sciences given by Harold E. Wise.[5] They were designed for Grades 1 through 14. Companion studies to cover the fields of biology, chemistry, and physics as well as science in the Junior High and the Elementary Schools, are underway at five centers of higher learning: at Chicago University; at Columbia, under S. Ralph Powers and Gerald S. Craig; at Michigan, under Frank Curtis; at New York University, under Martin S. Robinson; and at Boston University, under Vaden Miles.

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[5]Harold E. Wise, "A Determination of the Relative Importance of Principles of Physical Science for General Education", Science Education, XXV (December, 1941), #371-79; XXVI (January, 1942), 8-12; XXVII (February,1943), Pp. 67-76; XXVII (September-October, 1943), Pp. 67-76.

SURVEY OF IMPORTANT RESEARCH STUDIES PERTAINING TO THE DETERMINATION OF PRINCIPLES AS OBJECTIVES OF SCIENCE

Until comparatively recently, the only major objectives of science education were two-fold: (1) information; (2) appreciation of Divine work. In the middle of the 19th century, the religious objective was replaced, to a great extent, by the disciplinary one. Science was to train certain special faculties of the mind, a function which could not be done by any other study.

With the introduction of the scientific method in Education and Educational Psychology, the old aims were re-examined and a search was begun for new objectives. Often the new goals were stated in vague and general terms of little use to the average classroom teacher. Certain leading authorities were dissatisfied with the results and tried to find practical objectives useful to the classroom teacher.

As early as 1925, Downing[6] restated the principle, long accepted, that a scientific problem could be solved by discovering the relationshio between facts, and from these relationships, generalizations could be crystallized. In 1925, Craig[7] stated that the courses should include concepts and principles that are needed to understand everyday phenomens of interest to children. A year later, Heinemann[8], in an analysis of twenty general science

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[6]Elliot R. Downing, Teaching Science in the Schools, P. 93, Chicago - University of Chicago Press, 1925

[7]Gerald S. Craig, "Certain Techniques Used in Developing a Course of Study in Science for the Horace Mann Elementary School", Teachers College Contribution, Number 276, Pp. 12-13, New York

[8]Alice M. Heinemann, "A Study of General Science Textbooks", General Science Quarterly, XIII (November, 1928), Pp. 11-23

textbooks, defined a principle as a "statement of relationship frequently casual in nature between two facts". She found that ninety-three principles occupied only twelve percent of the entire reading space. She recommended that fewer principles be taught but more effectively.

Ninety-three principles were compiled by Downing[9] covering the fields of chemistry, physics, and biology. In his book he stated:

> "To guide pupils in the acquisition of the most important scientific knowledge so they may better control and explain their environment is one major goal of teaching science. This knowledge is usually applied to solving their problem of control or explanation only when it is in the form of principles. Scientific facts, unless organized to demonstrate or elucidate principles, are relatively useless. They do not function in problem-solving; they are soon forgotten.
>
> "If these things are true -- and the more one ponders them the more certain they seem -- then the science teacher who wishes to make his instruction conform to these truths, faces perplexity. The course of study he must follow is stated in terms of the materials to be studied rather than in terms of the principles that the pupils are to master.
>
> "It is hoped that in due time curriculum will be stated in terms of the outcome to be achieved by pupils and not in terms of the materials to be studied, and that as far as the knowledge, the thing mastered will be important principles".

Shortly afterwards, work on determining just what principles should be taught in secondary school science courses was undertaken at Chicago University, Teachers College, Columbia University, Colorado State Teachers College, and the University of Michigan. As a result of this activity, many defensible lists of science principles were formulated and gradually the work received greater recognition.

Beauchamp,[10] in his analysis of 165 courses of study, published in 1932,

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[9]Elliot Rowland Downing, An Introduction to the Teaching of Science, Pp. 39-48 Chicago: University of Chicago Press, 1934

[10]Wilbur L. Beauchamp, Instruction in Science., U.S. Office of Education Bulletin, 1932, No. 17, Monograph No. 22. Washington: Government Printing Office, 1933

states that (a) a shift has occurred from the organization of courses in terms of topics and sub-topics to organizations around certain major ideas or concepts. These ideas may be generalizations or principles of science or important ideas underlying the understanding and control of certain phases of man's environment; (b) a shift has taken place from the topical method of developing a topic to the problem method of development. Each problem is focused on some important idea or generalization of science.

Robertson[11] obtained a list of 112 principles for grade I to VI from analyzing eight masters' theses and submitting them for validation to fifteen science teachers. Criteria for a principle were determined and used to formulate the principles. The criteria used in this study follow:

(a) Must be a comprehensive generalization.
(b) Must be true without exception within the limitation specifically stated.
(c) Must be a clear statement of a process of interaction.
(d) Must be capable of illustration to gain conviction.
(e) Must not be part of a larger principle.
(f) Must not be a definition.
(g) Must not deal with a specific substance of variety or with a limited group of substances or species.

In 1930, Sites[12] conducted an investigation of textbooks and science magazines and decided on a list of forty-eight principles of ehcmistry. Lucas[13] made an analysis of current chemistry textbooks to determine what space was devoted to a discussion of principles.

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[11]Martin L. Robertson, "The Selection of Science Principles Suitable as Goals of Instruction in Elementary Science". Science Education, XIX (February, 1933), 1-4 (April, 1935), Pp. 65-70

[12]John T. Sites, "An Analysis of Chemical Articles in Three Science Magazines to Determine What Principles and Technical Terms Must Be Understood To Read Them Intelligently", Master's Thesis, University of Chicago, School of Education, 1924

[13]Loren T. Lucas, Analysis of Chemistry Texts in Terms of Principles, Master's Thesis, University of Chicago, Department of Education

Clarence Pruitt[14] made an exhaustive study of over fifty thousand pages of materials including examinations, newspapers and magazines. His list included 135 principles. He used the same criteria as Robertson and arranged his generalizations in order of their importance.

Edward James[15] compiled a list of fifty-four principles of chemistry for secondary school use at the Colorado State Teachers College. Doris Reek[16] made a study of four series of textbooks of science written specifically for grades I through VI to determine what principles of science are found in the elementary school. She found that there was little organization of textbooks to bring about the functional understanding of the principles.

Fleish[17] used the questions actually asked by Junior High general science and secondary school science pupils to set up a list of science principles. She discovered that about sixty principles should become the knowledge objectives of the general science course.

Jones[18] analyzed ninth-grade general science textbooks to find out the number of science principles which were actually used. In her analysis she

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[14]Clarence Martin Pruitt, Analysis, Evaluation, and Synthesis of Subject-Matter Concepts and Generalizations in Chemistry, Doctor's dissertation, Teachers College 1935. Distributed through Science Education. See Third Digest of Investigations in the Teaching of Science by Francis D. Curtis. Philadelphia; P. Blakiston's Son and Co., Inc., 1939

[15]Edward W. James, The Principles of Chemistry of Secondary Science Instruction. Unpublished Master's Thesis, Colorado State College of Education, Greely, Colorado, 1939. P. 81

[16]Doris Lucille Reek, A Study of the Principles of Science Found in Four Series of Textbooks of Elementary Science. Unpublished Master's Thesis, University of Michigan, 1943.

[17]Sylvia Fleish, The Formulation of the Science Principles That Should Become the Objectives of General Science Teaching in the Junior High School. Unpublished Master's Thesis, Boston University, 1945

[18]Ruth V. Jones, A Study of the Principles of Science Found in Ninth-Grade Textbooks of General Science. Unpublished Master's Thesis, University of Michigan, 1946

found a list of 146 principles.

Harold E. Wise,[19] by using lists formulated by Arnold, Hartman and Stephens, Pruitt and Robertson, developed a list of 272 principles of general science suitable for Grades I to XIV. It is generally accepted to be the most complete and reliable list yet formulated, and it is used in this research for applying the topics to the principles.

Vaden Miles[20] undertook to discover which principles were of definite value for an integrated course of physical science for grades X to XII by having five experienced science teachers mark the essential principles. His research found 103 principles which were deemed essential for this course.

Renato Leonelli[21] analyzed eight textbooks of general science for Grade VIII and found that most of the textbooks gave little space to the developing of principles. Steinwach[22] made a composite list of chemistry and physics principles in an unpublished thesis at Boston University.

Bergman[23] studies ten general science textbooks and thirty reference books dealing with entomology, plus other sources, to find 41 major principles and 5 minor principles of entymology. Spore and Hunter[24] submitted a list of 30 broad objectives.

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[19]Harold E. Wise, A Determination of The Relative Importance of Principles of Physical Science for General Education. Science Education XXV (December, 1941), Pp. 371-79, XXVI, (January, 1942) Pp. 8-12 XXVI, (February, 1943) Pp. 67-76; XXVII (September-October, 1943) Pp. 67-76

[20]Vaden W. Miles, An Unpublished Study Without Title, University of Michigan, 1947

[21]Renato E. Leonelli, Principles of Physical and Biological Science Found in Eight Textbooks of General Science for Grade VIII, Unpublished Master's Thesis, Boston University.

[22]C. M. Steinwach, Synthesis and Organization of Principles of Secondary School Chemistry and Physics, Unpublished Master's Thesis, Boston University

[23]George J. Bergman, "A Determination of the Principles of Entomology of Significance in General Education", Science Education, XXXI (February,1947), Pp.23-32

[24]G. W. Hunter and LeRoy Spore. "The Objective of Science in The Secondary School" School Science and Mathematics, XLIII (October 1943) Pp.633-47

SURVEY OF IMPORTANT RESEARCH STUDIES PERTAINING TO THE EFFECTIVENESS OF TEACHING PRINCIPLES IN TERMS OF THE RETENTION OF LEARNING

Tyler,[25] in a research to determine the relative retention of factual knowledge and the ability to generalize from facts, gave three tests at different times to a group of ninth grade pupils. The findings clearly showed there was little less in ability to generalize from everyday facts, whereas there was considerable loss in recall of facts.

Wert,[26] in a study at Ohio State University, discovered that factual memory decreased proportionally with the passage of each year. However, there was no loss in the ability to apply principles to the solution of new problems. Frutchey,[27] also at Ohio State University, discovered that in the retention of chemical facts, symbols, terminology, formula and valence, balance of equations, and the application of principles, the greatest amount of retention was in the application of principles.

SUMMARY OF RESEARCH STUDIES

From the evidence presented by the preceding investigations, it is proved that major generalizations and principles of science are important objectives of science teaching at all levels of general education.

Since Guy Montrose Whipple, a specialist in textbook writing, first

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[25]Ralph W. Tyler, "What High School Pupils Forget", Educational Research Bulletin, Ohio State University, IX (November 19, 1930)

[26]James E. Wert, "Twin Examination Assumption", Journal of Higher Education, VIII (March, 1937, Pp. 136-140

[27]F. P. Frutchey, "Retention in High School Chemistry", Educational Research Bulletin, Ohio State University, XVI (February, 1937) PP. 34-37

asked that a large part of science teaching be devoted to the understanding of principles and generalizations that ramify into human experiences and permit individual solution of problems, a great deal of research has served to prove this conclusion.

Elliot Downing of the University of Chicago first emphasized the importance of principles as important goals for science education. He first set up lists of principles which he recognized as incomplete but they did lay the foundation for further investigations. At the University of Michigan, Curtis directed the work of Robertson, Wise, and Martin in validating the principles for all levels of general education.

The effectiveness of teaching principles in terms of the retention of learning was substantiated by the researches of Tyler, Wert, and Frutchey. They discovered that facts are retained for a very short time, but broad generalizations and principles are retained for a longer time and are of great assistance in solving the every day problems of the learner. The classroom teacher of science must organize his course in terms of principles to be developed and not in isolated facts.

THE PROBLEM OF THIS INVESTIGATION

The purpose of this investigation is to determine the number of principles of chemistry actually found in four of the latest textbooks. This research is one of a series of studies of the contents of the latest textbooks of biology, chemistry, physics, and general science which are actually devoted to the teaching of validated principles of science. The result of this investigation, limited in range as it is by the inclusion of only four current texts, should help the classroom teacher to select the textbook most likely to assist in a fuller understanding of the prin-

ciples of science.

STATEMENT OF THE PROBLEM

This study is undertaken to determine the number of topics of four of the latest chemistry textbooks actually developing the understanding of the principle of science, validated by Harold Wise, and assigned by Waldo Emerson Blanchet[28] to Chemistry.

SCOPE AND LIMITATIONS OF THE INVESTIGATION

Only the list of principles of chemistry assigned by Waldo Emerson Blanchet from the study by Harold E. Wise is being used in this study. The textbooks were most recent editions but were not especially selected. They are written for secondary school use in the average high school class of chemistry. The criteria used in determining when a principle was actually developed by a topic were similar to that used by Leonelli[29] and given below:

1. Must be a comprehensive generalization or a part of a comprehensive generalization.
2. Must be true without exception within the limitation specifically stated.
3. Must not be a definition.
4. Must be demonstrable experimentally.
5. Must be stated definitely and/or may be implied in the writing of the author.
6. Must not deal with specific substances.

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[28] Waldo Emerson Blanchet, A Basis for the Selection of Course Content for Survey Course in the Natural Sciences, Unpublished Doctor's Dissertation, University of Michigan, 1946, Pp. vii-476.

[29] Renato E. Leonelli, Op. cit., P. 25.

CHAPTER II

RESEARCH

STATEMENT OF THE PROBLEMS

The purpose of this investigation was to determine the principles actually found in four of the latest chemistry textbooks. By using the list of science principles validated by Harold E. Wise and assigned by Waldo Emerson Blanchet to chemistry, four secondary school textbooks were analyzed to determine just what topics were used to teach principles of chemistry.

TECHNIQUE EMPLOYED

In the first step in the organization of the study, every boldface and inferred topic and sub-topic listed in each book was transferred to a three by five inch card. Using the purely subjective organization as proposed by Blanchet, an attempt was made to classify all topics and sub-topics under larger topic headings. A composite outline was set up with the elimination of all duplications, so far as is possible.

To determine the number of topics developing a principle, the criteria set up by other workers (Wise, Martin), were used. Each book, page by page, was searched for all possible evidence of the development of principles. Having assigned all topics to the appropriate principles, the validity of the assignment was checked by three experienced science teachers. Each checked the defensibility of the assignment of each of the topics to principles on the basis that the discussion of a topic might reasonably be expected to include materials contributary to developing an understanding of a principle. If any one of the three evaluators failed to accept the

placement of the topic under a principle, it is discarded or moved.

The initials which were used to indicate the books from which the principle or topic was found are as follows:

j. Jaffe, Bernard: New World of Chemistry Silver, Burdet and Co. New York, 1947

c. Kruh, Frank O: Carleton, Robert H; and Carpenter, Floyd F; Modern-Life Chemistry J.B. Lippincott Company, Chicago, 1941

w. Weaver, Elbert Cook; Forster, Lawrence Standley Chemistry For Our Times McGraw-Hill Book Co., Inc., New York 1947

a. Ahrens, Maurice R: Bush, Norris F: and Easley, Ray K; Living Chemistry Ginn and Company, 1946

The major topic headings were as follows:

NEW WORLD OF CHEMISTRY Bernard Jaffe

1. Matter and Its Changes
2. Oxygen: The Most Abundant Element
3. Hydrogen: Lightest of the Elements
4. Water: The Commonest Liquid Compound
5. Atoms: The Bricks of the Universe
6. Formulas: The Chemist's Universal Shorthand
7. The Atmosphere: The Ocean of Air In Which We Live
8. Equations: The Shorthand of Chemistry
9. The Mathematics of Chemistry
10. Chlorine and the Halogen Family
11. Electrons, Protons, and Neutrons
12. Atomic Energy at Last
13. Acids: Hydrochloric Acid, A Typical Acid
14. Bases: Sodium Hydroxide, A Typical Base
15. Solutions: Water, the Universal Solvent
16. Ions and the Importance of Ionization
17. Ammonia and Reversible Reactions
18. Nitric Acid and Other Compounds of Nitrogen
19. The Molecule and Avogadro's Hypothesis
20. Sulfur and Hydrogen Sulfide
21. Sulfuric Acid; The Fundamental Acid of Chemistry
22. Allotropic Carbon: Man's Present Chief Source of Energy
23. Carbon Dioxide: The Gas of Life and Decay
24. Carbon Monoxide and Other Gaseous Fuels
25. Metals and their Relative Chemical Activity
26. Aluminum: Commonest of the Light Metals
27. Iron and Steel
28. Copper: The Nerves of the Machine Age
29. Some Other Metals and Their Uses
30. Some Fertilizers and Salts of Sodium
31. Some Common Compounds of Calcium
32. Some Special Compounds of Iron
33. The Chemistry of Glass and Other Silicates
34. Petroleum and Other Hydrocarbons
35. Alcohol, Vinegar, Soap, and Some Other Common Organic Compounds
36. Foods, Vitamins, Hormones and Chemotherapy
37. Textiles, Paper, and Dyeing
38. The Colloidal State of Matter
39. Some Chemical Effects of Light

CHEMISTRY FOR OUR TIMES Weaver and Forster

Unit One: Our Essential Environment
- The Air
- Burning, Breathing, Rusting
- Hydrogen, the Lightest Gas
- Water
- The Nature of Gases, Liquids, Solids

Unit Two: Chemistry's Business Office
The Inventory - Atoms and Molecules
Shorthand and Transcription - Writing and Naming Formulas
Balanced Accounts - Equations
The Stock Room - Structure of the Atom

Unit Three: Dispersions of Matter
Solutions
Acids and Alkaline Solutions: Neutralizations
Electricity and Chemistry
Colloids

Unit Four: Chemistry of the Earth's Crust
The Earth and Its Ores
The Earth and Its Soil
Chemistry of the Sea - the Halogen Salts
Crystals of Commerce
The Great Classification

Unit Five: Chemical Industries
The Acid Heavy Chemicals
The Basic Heavy Chemicals
The Silicate Industries
Chemical Calculations

Unit Six: The Metals
Iron and Steel
The Light Metals
The Denser Metals
Corrosion - Harmful or Helpful

Unit Seven: The Chemistry of Carbon Compounds
The Nature of Carbon Compounds
Our Fuels
Plant and Animal Chemistry
Cellulose and Plastics
Coal-tar Chemistry

Unit Eight: Chemistry and Human Problems
Food and Chemistry
Chemistry for Cleanliness, Health and Beauty
Chemistry for Safety, Peace, and War

Unit Nine: Additional Topics
Radioactivity
Chemistry and Radiant Energy
The Noble Metals and Some Less Familiar Elements
What Lies Ahead

MODERN LIFE CHEMISTRY Kruh-Carpenter Carleton

Unit One: Foundations of Chemistry
How does the Chemist Recognize and Classify the Materials with which he Works?
What Changes Does Matter Undergo?
Why Is Oxygen Such an Important Element?
What Fundamental Chemical Laws Are Illustrated by the Compounds of Oxygen and Hydrogen?

Unit Two: The Structure of Matter
Why Does the Chemist Believe Molecules are Composed of Atoms?
Why Does the Chemist Believe Matter Is Composed of Molecules?
What is Meant by Molecular and Atomic Weights?
How Do Atoms Seem to Be Constructed?
How Does the Electron Theory Explain the Combining of Atoms?
What Do Chemical Symbols and Formulas Mean?

Unit Three: Solutions and Near-Solutions
How are Substances Put into Solution?
How Does the Molecular Theory Account for the Regularities Observed in the Behavior of Solutions?
How Are Dissolved Substances Recovered from Solutions?
What Is the Nature and Importance of Colloids?

Unit Four: Chemical Action in Solution
How Does the Theory of Dissociation Provide an Explanation for Chemical Reactions in Solution?
How Does the Theory of Dissociation Account for Electrochemical Reactions?
How Does the Theory of Dissociation Account for the Properties and Behavior of Electrolytes?
How Are Acids, Bases, and Salts Prepared, and How Are They Named and Classified.

Unit Five: Chemical Equations and Calculations
What Do Chemical Equations Mean?
How Are Molecular Equations Written and Balanced?
How Can Problems Based on Chemical Equations Be Solved?

Unit Six: Sulfur and Its Compounds
How Is Sulfur Obtained and for What Is It Used?
How Is Sulfur Related to the Rubber Industry?
How Is Hydrogen Sulfide Used in Chemical Analysis?
How May Sulfur Dioxide Be Prepared and For What Is It Used?
Why Is Sulfuric Acid the Most Important Compound of Sulfur?

Unit Seven: The Halogens And the Periodic Classification
What Are the Characteristics of Chlorine?
What Is the Electronic Explanation for Oxidation and Reduction?
How Is the Most Important Acid of Chlorine Made and Used?

Why Are Fluorine, Chlorine, Bromine, and Iodine Called the Halogen Family?
What Is the Nature and Value of the Periodic Classification?

Unit Eight: The Nitrogen Family
Of What Importance Is the Most Abundant Constituent of the Atmosphere?
How is Ammonia Prepared and Used?
How Is the Most Important Acid of Nitrogen Made and Used?
How Does the Behavior of the Elements in the Nitrogen Family Support the Periodic Classification of the Elements?
How Is the Nitrogen Family Related to the Chemistry of Agriculture?

Unit Nine: Mineralogy and Chemistry
What Is the Nature of Mineralogy?
How Are the Important Minerals of Sodium and Pottasium Obtained and Used?
What are the Important Calcium and Magnesium Minerals and How Are They applied?
What Are the Characteristic Properties and Compounds of the Central Elements of the Mineral World?

Unit Ten: Metallurgy And Chemistry
How Are The Common Metals Extracted and Refined?
What Is the Nature and Value of Alloys?
How Are Metals Protected Against Corrosion?
In What Ways Are Compounds of the Metals Used?

Unit Eleven. Organic Chemistry
What Are the Characteristic Properties and Uses of Carbon and Its Oxides?
How Are The Common Natural and Artificial Fuels Obtained and Used?
How Are the Properties of Hydrocarbon Compounds Explained by Their Molecular Structure?
How Can We Apply the Idea of Molecular Structure to Explain the Classification and Properties of Hydrocarbon Derivatives?
How May We Classify Those Carbon Compounds Which Provide Food and Clothing, and What Are Some of Their Characteristics?

Chemistry Marches On

Recent Chemical Contributions to Health and Safety.
Recent Chemical Contributions to Conservation and National Security
Recent Developments in Plastics and Synthetics
Recent Chemical Contributions to the home.
What is the Future of Chemistry?

LIVING CHEMISTRY Ahrens Bush and Easley

PART I - FUNDAMENTALS OF CHEMISTRY

Unit One: Chemistry Improves Man's Living
Unit Two: The Material World: Matter
Unit Three: Forces at Work: Energy
Unit Four: The Structure of Matter
Unit Five: Chemical Formulas
Unit Six: Oxygen
Unit Seven: Hydrogen
Unit Eight: Solutions and Ionization
Unit Nine: Chemical Equations
Unit Ten: Acids, Bases, Salts and Oxides.

PART II - CHEMISTRY OF THE INDIVIDUAL

Unit Eleven: The Chemistry of Water in the Body Unit
Unit Twelve: The Chemistry of Foods and Nutrition
Unit Thirteen: Glands of Internal Secretion
Unit Fourteen: The Chemistry of Disease
Unit Fifteen: The Chemistry of Drugs and Medicines
Unit Sixteen: The Chemistry of Cosmetics
Unit Seventeen: The Chemistry of Clothing
Unit Eighteen: Chemical Hobbies
Unit Nineteen: Vocations Related to Chemistry

PART III - CHEMISTRY OF THE HOME

Unit Twenty: The Chemistry of the Cooking and Preservation of Food
Unit Twenty-One: The Chemistry of Cooking Utensils
Unit Twenty-Two: The Chemistry of Tableware
Unit Twenty-Three: The Chemistry of Fuels and Heating
Unit Twenty-Four: The Chemistry of Refrigeration and Ir-Conditioning
Unit Twenty-Five: The Chemistry of Sanitation in the Home
Unit Twenty-Six: The Chemistry of Materials Used in Modern Home Construction
Unit Twenty-Seven: The Chemistry of Home Decorations
Unit Twenty-Eight: The Chemistry of Gardening

PART IV - CHEMISTRY OF THE COMMUNITY

Unit Twenty-Nine: The Chemistry of Water Purification
Unit Thirty: The Chemistry of the Disposal of Sewage and Other Wastes
Unit Thirty-One: The Chemistry of Food Production and Distribution
Unit Thirty-Two: Chemistry in Industry
Unit Thirty-Three: Chemistry in a Changing World

TABLE I

COMPOSITE OUTLINE OF TOPICS	J	C	W	A
MATTER AND ITS CHANGES				
History	x	x	x	x
States				
solid	x	x	x	x
liquid	x	x	x	x
gaseous	x	x	x	x
Changes				
physical	x	x	x	x
chemical	x	x	x	x
Composition and classification of matter				
elements	x	x	x	x
compounds	x	x	x	x
mixture	x	x	x	x
difference between compound and mixture	x	x	x	x
Law of conservation of matter				
applications	x	x	x	x
importance of law	x	x	x	x
careful weighing and law	x	x	x	x
Energy				
definition	x	x	x	x
examples of energy changes	x	x	x	x
potential energy	x	x	x	x
kinetic energy	x	x	x	x
Kinetic molecular theory	x	x	x	x
Properties of matter				
physical	x	x	x	x
chemical	x	x	x	x
how to identify a substance	x	x	x	x
Scientific method				
steps in scientific method	x	x	x	x
everyday uses	x	x	x	x
cause and effect relationship	x	x	x	x
Terms to describe the purity of a substance				x
Names and symbols of elements	x	x	x	x
Importance of chemistry				
Science in action	x	x	x	x
Benefits from science research	x	x	x	x
The value of chemistry study	x	x	x	x
How to improve your knowledge of chemistry			x	
Reasons for studying chemistry				x

TABLE I (CONTINUED)

COMPOSITE OUTLINE OF TOPICS	J	C	W	A
OXYGEN				
History	x	x	x	x
Lavoisier, Priestley	x	x	x	x
Occurrence	x	x	x	x
Preparation	x	x	x	x
laboratory	x	x	x	x
catalysis	x	x	x	x
equation	x	x	x	x
speed of reactions	x	x	x	x
commercial	x	x	x	x
electrolysis	x	x	x	x
liquid air	x	x	x	x
Properties	x	x	x	x
physical	x	x	x	x
color, odor, taste, weight, solubility	x	x	x	x
chemical	x	x	x	x
activity	x	x	x	x
oxides, test	x	x	x	x
slow oxidation	x	x	x	x
breathing, rusting	x	x	x	x
rapid oxidation	x	x	x	x
combustion	x	x	x	x
kindling temperature	x	x	x	x
spontaneous combustion	x	x	x	x
explosive mixtures	x	x	x	x
dust explosions	x	x	x	x
uses	x	x	x	x
industry	x	x	x	x
oxyacetylene, oxyhydrogen torches	x	x	x	x
deseaming scale	x	x	x	x
oxygen tents	x	x	x	x
basal metabolism	x	x	x	x
high altitude flying	x	x	x	x
flashlights	x	x	x	x
Allotrophy	x	x	x	x
Ozone	x	x	x	x
properties	x	x	x	x
preparation	x	x	x	x
uses	x	x	x	x
Phosphorus	x	x	x	x
kinds	x	x	x	x
white, red	x	x	x	x
uses	x	x	x	x

TABLE I (CONTINUED)

COMPOSITE OUTLINE OF TOPICS	J	C	W	A
HYDROGEN				
History	x	x	x	x
Lavoisier	x	x	x	x
Priestley	x	x	x	x
Occurrence	x	x	x	x
Preparation	x	x	x	x
Laboratory	x	x	x	x
Commercial	x	x	x	x
equation	x	x	x	x
speed of reaction	x	x	x	x
catalyst	x	x	x	x
Properties	x	x	x	x
Physical	x	x	x	x
collection of gas	x	x	x	x
Chemical	x	x	x	x
experimental proof water forms	x	x	x	x
relation of reduction to oxidation	x	x	x	x
Uses	x	x	x	x
Lighter than air	x	x	x	x
Hydrogenation	x	x	x	x
Ammonia synthesis	x	x	x	x
Heating	x	x	x	x
Blow torch atomic hydrogen	x	x	x	x
Hydrogen and activity series	x	x	x	x
THE ATMOSPHERE				
History	x	x	x	x
Mixture	x	x	x	x
Proof air is mixture	x	x	x	x
Proof air has weight			x	
Proof air has pressure			x	
Nitrogen	x	x	x	x
Occurrence	x	x	x	x
Preparation	x	x	x	x
laboratory	x	x	x	x
commercial	x	x	x	x
Properties	x	x	x	x
physical	x	x	x	x
chemical	x	x	x	x
Uses	x	x	x	x
Rare gases	x	x	x	x
Neon	x	x	x	x
Argon	x	x	x	x
Helium	x	x	x	x
Krypton	x	x	x	x
uses of rare gases	x	x	x	x
Water vapor			x	
Liquification of air			x	

TABLE I (CONTINUED)

COMPOSITE OUTLINE OF TOPICS	J	C	T&E	A
WATER				
History	x	x	x	x
Preparation	x	x	x	x
Electrolysis	x	x	x	x
Composition molumetric	x	x	x	
Gravimetric	x	x	x	
Law of Definite Proportions	x	x	x	x
Properties of water	x	x	x	x
Physical	x	x	x	x
Specific heat	x	x	x	x
Chemical				
Water of crystallization	x	x	x	x
Efflorescence	x	x	x	x
Deliquescence	x	x	x	x
Uses	x	x	x	x
Occurrence	x	x	x	x
Pure water supply	x	x	x	x
Methods of purification	x	x	x	x
SOLUTIONS				
Solution	x	x	x	x
Dilute	x	x	x	x
Concentrated	x	x	x	x
Saturated	x	x	x	x
Supersaturation	x	x	x	x
Factors Controlling solutions	x	x	x	x
Effects of Solutes	x	x	x	x
Suspensions	x	x	x	x
Distillation				
Heavy Water	x	x	x	x
Fractional distillation	x	x	x	x
Water purification	x	x	x	x
Sewage purification	x	x	x	x
Anerobic bacteria				x
MOLECULE AND AVOGADRO'S HYPOTHESIS				
History molecule	x	x	x	x
Boyle's and Charles'laws	x	x	x	x
Gay-Lussac law	x	x	x	x
Avogadro's Hypothesis	x	x	x	x
Value	x	x	x	x
Verified	x	x	x	x
(Principle of atomic-Hydrogen torch)	x	x	w	x

TABLE I (CONTINUED)

COMPOSITE OUTLINE OF TOPICS	J	C	W&F	A
Avogadro's Hypothesis (Continued)				
Proof that molecule of hydrogen contains 2 atoms	x	x	x	x
Gram - Molecular Volume	x	x	x	x
Problems Weight and Volume	x	x	w	x
Straight Volume Problems	x	x	w	x
EQUATIONS SHORTHAND OF CHEMISTRY				
Chemical changes represented	x	x	x	x
How to balance an equation	x	x	x	x
Four types of chemical equations	x	x	x	x
What causes reactions to go to completion	x	x	x	x
THE MATHEMATICS OF CHEMISTRY				
Atomic weights are relative	x	x	x	x
Dalton prepares atomic weights	x	x	x	x
Atomic weights	x	x	x	x
Table basis of math.	x	x	x	x
Solving type problems	x	x	x	x
1. Molecular weight	x	x	[illegible]	x
2. Percentage composition	x	x	x	x
3. Chemical equations	x	x	[illegible]	x
4. Straight weight problems	x	x	[illegible]	x
5. Straight volume problems	x	x	x	x
6. Both weight and volume	x	[illegible]	[illegible]	x
IONIC AND IONIZATION				
Theory of Ionization What? Why?	x	x	[illegible]	x
Arrhenius Theory	x	x	x	x
Ion differences from atom	x	x	x	x
Electrolytes	x	x	x	x
Occurence of Ions	x	x	[illegible]	x
Acids and bases	x	x	x	x
pH constants	x	x	x	x
Degree of Dissociation	x	x	x	x
Physical properties of Abnormal freezing and boiling	[illegible]	x	x	x
Hydrolysis	x	x	x	x
Opposite of Neutralization	x	x	x	x
Reversible reactions	x	x	[illegible]	x
Equations going to completion	x	x	x	x
Law of Mass Action	x	x	x	x
Common Ion Effect	x	[illegible]	x	x
Naming of acids, bases and oxides	x	x	x	x

TABLE I (CONTINUED)

COMPOSITE OUTLINE OF TOPICS	J	C	[illegible]	A
OXIDES	x	x	x	x
Preparation	x	x	x	x
General methods of	x	x	x	x
Properties of	x	x	x	x
Special cases of burning	x	x	x	x
ELECTRON PROTON AND NEUTRON	x	x	x	x
History	x	x	x	x
Discovery of Proton	x	x	x	x
Discovery of electron	x	x	x	x
Structure of atom	x	x	x	x
Miniature solar system	x	x	x	x
Electron	x	x	[illegible]	x
Proton	x	x	x	x
Neutron	x	x	x	x
Law of Atomic numbers	x	x	x	x
Periodic numbers	x	x	x	x
Mendeleyeff	x	x	x	x
Changing theories	x	x	x	x
Isotopes	x	x	x	x
Heavy water	x	x	x	x
Explanation by electron theory	x	x	x	x
Metallic structure	x	x	x	x
Valence	x	x	x	x
Amphoteric compounds	x	x	x	x
Chemical union	x	x	x	x
Polar compounds	x	x		x
Oxidation	x	x	x	x
Reduction	x	x	x	x
ATOMS	x	x	x	x
History	x	x		x
Democritus	x	x		x
Newton	x	x	x	x
Dalton's Atomic Theory	x	x	x	x
Explains law of definite proportions	x	x	x	x
Discovers law of multiple proportions	x	x	x	x
Hydrogen peroxide	x	x	x	x
Preparation	x	x	x	
Properties	x	x	x	
Uses	x	x	x	
Formulas, the chemist's universal shorthand				
History	x	x	x	
Formulas represent molecules	x	x	x	x
Symbol represents atom	x	x	x	x
Subscripts represent number of atoms in mole	x	x	x	x

TABLE I (CONTINUED)

COMPOSITE OUTLINE OF TOPICS	J	C	W&F	A
CHLORINE AND THE HALOGEN FAMILY				
History	x	x	x	
Preparation - chlorine	x	x	x	
Properties	x	x	x	x
Science serves humanity	x	x		x
Uses	x	x	x	x
Bleaching effect	x	x	x	x
Life saving	x	x	x	x
Antiseptic, Disinfectant	x	x	x	x
Gas	x	x	x	x
Test	x	x	x	x
		x	x	x
Halogens	x	x	x	x
Bromine	x	x	x	x
Preparation ses water	x	x	x	x
Uses	x	x	x	x
Iodine	x	x	x	x
Preparation	x	x	x	x
Uses	x	x	x	x
Fluorine	x	x	x	x
Uses	x	x	x	x
Hydrofluoric acid	x	x	x	x
Non-metal activity series.	x	x	x	x
Refrigerants	x		x	x
Tooth decay	x		x	x
Tests for bromine and iodine halogens	x	x	x	x
AMMONIA AND REVERSIBLE REACTIONS				
Electron structure	x	x	x	
Preparation	x	x	x	x
Properties	x	x	x	x
Uses	x	x	x	x
Nitric Acid	x	x	x	x
Nitrates	x	x	x	x
Refrigerant	x	x	x	x
Water Purification	x	x	x	x
Ammonium Hydroxide	x	x	x	x
Preparation	x	x	x	x
Properties	x	x	x	x
Ammonium Salts	x	x	x	x
Haber Process	x	x	x	x
Reversible Reactions	x	x	x	x
Factors Controlling Point of Equilibrium	x	x	x	x
Gyanamide Process	x	x	x	x
History	x	x	x	

TABLE I (CONTINUED)

COMPOSITE OUTLINE OF TOPICS	J	C	W&F	A
IRON AND STEEL	x	x	x	x
Occurrence and Importance	x	x	x	x
Metallurgy of Iron	x	x	x	x
Blast Furnace	x	x	x	x
Pig Iron	x	x	x	x
Composition	x	x	x	x
Properties	x	x	x	x
Uses	x	x	x	x
Cast Iron	x	x	x	x
Wrought Iron	x	x	x	x
History	x	x	x	x
Bessemer process	x	x	x	x
Open Hearth process	x	x	x	x
Steel	x	x	x	x
Composition	x	x	x	x
Properties	x	x	x	x
Tempering	x	x	x	x
Induction furnace	x	x	x	x
Alloys of Steel	x	x	x	x
Case-hardening	x	x	x	x
Analyzing steel	x	x	x	x
Heat tratement	x	x	x	x
Processing steel	x	x	x	x
METALS AND CHEMICAL ACTIVITY				
Classification of metals and nonmetals	x	x	x	x
Occurrence	x	x	x	x
Methods of extraction	x	x	x	x
Properties of metals	x	x	x	x
Physical	x	x	x	x
Chemical	x	x	x	x
Replacement Series of Common Metals	x	x	x	x
Electron explanation of metals	x	x	x	x
Electron explanation of non-metals	x	x	x	x
Use of replacement series	x	x	x	x
Alkali Metals	x	x	x	x
Sodium & Pottassium	x	x	x	x
Preparation	x	x	x	
Properties	x	x	x	
Physical	x	x	x	
Chemical	x			
tests	x			
Uses	x			
Spectroscope	x	x	x	x
Principle				

TABLE I (CONTINUED)

COMPOSITE OUTLINE OF TOPICS	J	C	W&F	A
SILICATES AND GLASS				
Silicon	x	x	x	x
Silica	x	x	x	x
Silicon Carbide	x	x	x	x
Abrasives	x	x	x	x
Water Glass	x	x	x	x
Silica gel	x	x	x	x
Glass				
Importance	x	x	x	x
Composition	x	x	x	x
Special glasses	x	x	x	x
Plate glass	x	x	x	x
Invisible glass	x	x	x	x
Shatterproof glass	x	x	x	x
Uses of glass in construction	x	x	x	x
Mirrors construction	x	x	x	x
Enamelware	x	x	x	x
Quartz glass	x	x	x	x
Clay	x	x	x	x
Pottery	x	x	x	x
Cement	x	x	x	x
Preparation	x	x	x	x
Properties	x	x	x	x
Cosmetics	x	x	x	x
Talc	x	x	x	x
Borax	x	x	x	x
SULFURIC ACID	x	x	x	x
Fundamental chemicals	x	x	x	x
Sulfur Dioxide	x	x	x	x
Preparation	x	x	x	
Properties	x	x	x	
Uses	x	x	x	
Sulfurous Acid	x	x	x	x
Properties	x	x	x	x
Uses of Sulfurous Acid, Sulfites, and Bisulfites	x	x	x	
Test	x	x	x	
Sulfur Trioxide	x	x	x	x
Contact process	x	x	x	x
Lead chamber process	x	x	x	x
Properties of sulfuric acid	x	x	x	
Uses	x	x	x	x
Agriculture	x	x	x	x
Salts	x	x	x	x
Test	x	x	x	x
Making acids	x	x	x	

TABLE I (CONTINUED)

COMPOSITE OUTLINE OF TOPICS	J	C	T&F	A
ACIDS	x	x	x	x
Properties	x	x	x	x
Heat	x	x	x	x
Exothermic	x	x	x	x
Endothermic	x	x	x	x
Heat of Formation	x	x	x	x
Properties of heats of formation	x	x	x	x
History	x	x	x	x
Preparation	x	x	x	x
Electron explanation of all acids	x	x	x	x
Properties	x	x	x	x
Molar and normal solutions	x	x	x	x
Uses of hydrochloric acid	x	x	x	x
Hydrogen gas chloride	x	x	x	x
Properties	x	x	x	x
Volumetric composition	x	x	x	x
Hydrogen fluoric acid	x	x	x	x
Uses As etching Agent	x	x	x	x
Halogen Acids	x	x	x	x
BASES	x	x	x	x
Sodium Hydroxide	x	x	x	x
Properties	x	x	x	x
Typical properties of bases	x	x	x	x
Preparation	x	x	x	x
Typical preparation of bases	x	x	x	x
Neutralization	x	x	x	x
Heat of neutralization	x	x	x	x
Uses	x	x	x	x
Clothing	x	x	x	x
Rayon, Cellulose	x	x	x	x
Soaps	x	x	x	x
Lye	x	x	x	x
Peeling vegetables, fruits	x	x	x	x
Reclaiming waste metals	x	x	x	x
SALTS	x	x	x	x
Preparation	x	x	x	x
General methods of	x	x	x	x
Neutralization	x	x	x	x
Acid on metal	x	x	x	x
Union of metal and nonmetal	x	x	x	x
Action of acid on metallic oxide	x	x	x	x
Action of acid on more volatile acid	x	x	x	x
Reaction between two salts	x	x	x	x
Basic oxide on acidic oxide	x	x	x	x

TABLE I (CONTINUED)

COMPOSITE OUTLINE OF TOPIC	J	C	W&F	A
PETROLEUM AND OTHER HYDROCARBONS				
Hydrocarbons	x	x	x	x
Properties	x	x	x	x
Methane	x	x	x	x
Series of Compounds	x	x	x	x
Isomerism	x	x	x	x
Petroleum	x	x	x	x
Refining	x	x	x	x
Gasoline	x	x	x	x
Knocking	x	--	x	x
Octane numbers	x	--	x	x
Cracking gasoline	x	x	x	x
Conservation of gasoline	x	--	x	x
Benzene	x	x	x	x
Chloroform	x	x	x	x
Iodoform	x	--	--	x
Carbon Tetrchloride	x	x	x	x
Aniline	x	--	x	x
Sources of Rubber	x	x	--	x
Processes of Rubber	x	x	x	x
Synthetic rubber	x	x	x	x
Buna S.	x	--	x	x
Naphthalene	x	--	x	x
Moth control	x	--	--	x
Turpentine	x	--	--	x
D.D.T.	x	--	--	x
ALCOHOL, VINEGAR, SOAP, AND SOME OTHER ORGANIC COMPOUNDS				
Alcohol	x	x	x	x
Methyl	x	x	x	x
Distructive Distillation	x	--	x	x
Ethyl	x	x	x	x
Preparation of grain alcohol	x	x	--	x
Uses	x	x	x	x
Power alcohol	x	--	x	x
Chemurgy	x	--	--	x
Butyl Alcohol	x	x	x	x
Glycerin	x	x	x	x
Acetic Acid	x	--	x	x
Organic Acids	x	x	x	x

TABLE I (CONTINUED)

COMPOSITE OUTLINE OF TOPICS	J	C	W&F	A
COLLOIDAL STATE OF MATTER				
Colloid	x	x	x	x
Properties of colloids	x	x	x	x
Preparations of dispersions	x	x	x	x
Sols and gels	x	x	x	x
Emulsifying Agents	x	x	x	x
Precipitation of colloids	x			
Acids and alkalies				
Adsorption and colloidal state	x	x	x	x
Colloidal state	x	x	x	x
Stabilizing colloidal dispersions	x	x	x	x
Common applications of colloid chemistry	x	x	x	x
CHEMICAL EFFECTS OF LIGHT				
Nature of light	x	x	x	x
Effects of light	x	x	x	x
Why?	x	x	x	x
Photography	x	x	x	x
Chemical reactions	x	x	x	x
Color photography	x	x	x	x
Photography as a hobby	x	x	x	x
X-Rays	x	x	x	x
Photography	x	x	x	x
Crystal structure	x	x	x	x
Mechanism of the human eye			x	
Future of chemistry	x	x	x	x
Photosynthesis	x	x	x	x
How firefly lights its lantern		x	x	
Action of sunlight on the upper atmosphere	x		x	
Toning of prints				x
Motion pictures				x
The home laboratory				x
COMPOUNDS OF IRON				
Two series of compounds	x	x	x	x
Ferrous chloride	x	x	x	x
Ferric chloride	x	x	x	x
Tests	x	x	x	x
Uses reduction of ferric to ferrous	x	x	x	
Blueprints	x	x	x	x
Writing inks	x	x	x	x
Removing ink stains	x	x		x
Sympathetic inks	x	x		
Bluing	x	x		x
Lodestone magnetic properties	x	x	x	x
Rouge	x	x	x	x

TABLE I (CONTINUED)

COMPOSITE OUTLINE OF TOPICS	J	C	W&F	A
FERTILIZERS				
History	x		x	x
Conservation	x			x
Potassium salts	x	x	x	x
Potash problem	x	x		x
Feldspar as Source of Fertilizers	x	x		x
Potassium Nitrate	x	x	x	x
Hyponics	x	x		x
Properties of salts of alkali metals	x		x	x
Sodium Nitrate	x	x		x
Sodium Chloride	x	x	x	x
Uses	x			x
Sodium Bicarbonate	x	x	x	x
Preparation	x	x	x	x
Sodium Carbonate	x	x	x	x
in glass	x	x	x	x
in soap	x	x	x	x
softening water	x	x	x	x
CALCIUM	x	x	x	x
Alkali metals	x		x	x
Calcium	x	x	x	x
Barium	x	x		x
Strontium	x	x		x
Radium	x	x	x	x
Calcium Carbonate	x	x	x	x
Limestone Caves	x	x	x	x
Lime, Calcium Oxide	x	x	x	x
Uses	x	x	x	x
Slaked lime	x	x	x	x
Limelights	x		x	x
Fertilizers	x	x		x
Construction	x		x	x
Clacium Sulfate	x	x		x
Plaster of Paris	x	x		x
Superphosphate of Ca.	x			x
C.V.A.	x			x
Calcium Phosphate source of Pure Phosphorus	x		x	x
Hard Water	x	x	x	x
Softening of Hard Water	x	x	x	x
Sea Water Purified	x	x	x	x

TABLE I (CONTINUED)

COMPOSITE OUTLINE OF TOPICS	J	C	W&F	A
SULFUR AND HYDROGEN SULFIDE	x	x	x	x
History	x	x	x	x
Preparation or extraction	x	x	x	x
Frasch	x	x	x	x
Scilly	x			
Properties	x	x	x	x
Physical	x	x	x	x
Allotropic forms	x	x	x	x
Chemical	x	x	x	x
Uses	x	x	x	x
Rubber	x	x	x	x
Sulfuric Acid	x	x	x	x
Bug control	x	x	x	x
Medicine	x	x	x	x
Bisulfite	x	x	x	x
Matches	x	x	x	x
Hydrogen Sulfide	x	x	x	x
Preparation	x	x	x	x
Properties	x	x	x	x
Sulfides Occurrence	x	x	x	x
Uses	x	x	x	x
Tests for sulfides	x	x	x	x
ALLOTROPIC CARBON	x	x	x	x
Carbon Chemistry	x	x	x	x
Valence	x	x	x	x
Properties	x	x	x	x
Chemical	x	x	x	x
Physical	x	x	x	x
Hardness	x	x	x	x
Allotropic diamond forms	x	x	x	x
Soot	x	x	x	x
Graphite	x	x	x	x
Coke	x	x	x	x
Charcoal	x	x	x	x
Animal Charcoal	x	x	x	x
Isotopes of carbon		x		
Coal	x	x	x	x
Formation	x	x	x	x
Kinds	x	x	x	x
Uses	x	x	x	x
Consumer	x	x	x	x
Energy Sources	x	x	x	x
Synthetic fuels from coal	x	x	x	x

TABLE I (CONTINUED)

COMPOSITE OUTLINE OF TOPICS	J	C	W&F	A
Esters	x	x	x	x
Perfumes	x	x	x	x
Fats	x	x	x	x
Animal	x	x	x	x
Vegetable	x	x	x	x
Soaps	x	x	x	x
Hard	x	x	x	x
Soft	x	x	x	x
Insoluble	x	x	x	x
Cleansing Action	x	x	x	x
Hard Waters Action	x	x	x	x
Consumers of Soap	x	x	x	x
Detergents	x	x	x	x
Acetone, Ether and Formaldehyde	x	x	x	x
FOODS, VITAMINS, HORMONES AND CHEMOTHERAPY				
Carbohydrate	x	x	x	x
Starch Photosynthesis	x	x	x	x
Starch in Laundry	x	x	x	x
Sugar	x	x	x	x
Sucrose	x	x	x	x
Saccharin	x	-	x	-
Inversion of Cane Sugar	x	x	x	x
Wood Synthesis	x	-	-	-
Fats And Oils	x	x	x	x
Hydrogenation Of Oils	x	x	x	x
Proteins	x	x	x	x
Food Minerals	x	x	x	x
Calories	x	x	x	x
Balanced Diet	x	x	x	x
Vitamins	x	x	x	x
Hormones	x	x	x	x
Chemotheraphy	x	x	x	x
Sulfa Drugs	x	x	x	x
Quinine	x	x	x	x
Natural	x	-	-	-
Artificial	x	-	-	-

TABLE I (CONTINUED)

COMPOSITE OUTLINE OF TOPICS	J	C	W&F	A
Penicillin				
Preparation	x	-	x	x
Textiles, Paper and Dyeing	X	x	x	x
Fibers	x	x	x	x
Characteristics	x	x	-	x
Cotton	x	x	-	x
Wool	x	x	-	x
Silk	x	x	-	x
Rayon	x	x	-	x
Viscose	x	x	-	x
Acetate rayon	x	x	-	x
Lanital	x	x	-	x
Cellophane	x	x	-	x
Nylon	x	-	X	x
Economic effects	x	-	x	x
Fiberglass	x	-	x	x
Paper	x	x	x	x
Nitrocellulose	x	x	x	x
Plastics	x	x	x	x
Some Important Plastics	x	x	x	x
Silicones	x	-	-	-
Dyes	x	x	x	x
Analine Dyes	x	x	x	x
Processes	x	x	x	x

FINDINGS, TABLE I

From a study of the composite outline, it is apparent that most of the topics are common to all the books. All the books devoted almost equal space to the major topics demanded by the College Entrance Examination Board and the New York Regents syllabi. Modern Life Chemistry by Kruh, Carleton and Carpenter is organized around certain ideas, principles, generalizations, and aspects of chemistry which constitute the units of the course. New World of Chemistry by Jaffe had the most complete description of most of the principles of chemistry as well as the greatest amount of subject matter. Living Chemistry by Ahrens, Bush and Easley is designed for the terminal student. Chemistry For Our Times by Weaver and Forster had excellent experimental evidence for most of the principles of chemistry.

Greater emphasis is being placed upon the chemical facts relating to soils, foods, and body processes. The atomic theory is explained in greater detail as are some of the newer scientific discoveries. The historical approach is developed to a further extent than earlier books. Non-metals and their compounds were, in most cases, found under new major topics relating to the earth and sea. Greater use is made of the electron theory in presenting new elements and their compounds. Calculations are given a more prominent place in the books. The metals were first given as a group with the general properties explained and less importance given to the rarer metals.

TABLE II

ASSIGNMENT OF THE TOPICS OF CHEMISTRY FOUND IN THE FOUR HIGH SCHOOL CHEMISTRY BOOKS TO THE SIXTY-SIX CHEMISTRY PRINCIPLES

Principle and Assigned Topics	Books
CHEMISTRY	
(2) Every pure sample of any substance, whether simple or compound, under the same conditions will show the same physical properties and the same chemical behavior.	
What is a physical change?	j
How is a substance identified?	j
Physical and Chemical properties of:-	
Oxygen, Iron, Lead	
Hydrogen, Copper, Zinc	
Halogen, Aluminum, Cobalt	
Nitrogen, Nickel, Tin	
Sulfur, Magnesium, Chromium	
Carbon, Mercury, Platinum	j,w,c
How do we recognize matter?	j
Mixture and a pure substance	a
Chemical properties also aid in determination of substance	a
Physical properties by which you can identify a substance	a
What are physical and chemical properties?	a
Primitive man and his knowledge of matter	w
The decline of alchemy	w
Physical and chemical properties of matter	c
How does the chemist recognize and classify materials with which he works?	c
How can you recognize matter?	a
Terms used to describe purity	a
What are the properties of matter?	w
(6) Oxidation and reduction occur simultaneously and are quantitatively equal.	
How the electron theory explains oxidation and reduction	j
Oxidation and Reduction in terms of electrons	c
What is the relation of oxidation to reduction	j
Oxidation and reduction	w,c
Electron transfer	w
The meaning of oxidation and reduction	a

TABLE II (CONTINUED)

Principle and Assigned Topics	Books
(7) Oxidation always involves the removal or sharing of electrons from the element oxidized while the reduction always adds or shares with the element reducted.	
How the electron theory explains oxidation and reduction	j
Oxidation and reduction in terms of electrons.....	c
Oxidation and reduction.....	c
Electron transfer.....	w
The meaning of oxidation and reduction	a
(14) The materials forming one or more substances, without ceasing to exist, may be changed into one or more new and measurably different substances.	
Chemical changes	j
Chemical and physical changes	w
Kinds of chemical changes	w
When has a substance been changed?.....	a
Types of a chemical reaction	a
Chemical changes of matter	c
Matter undergoes many changes	j
How does a chemical change differ from a physical change	j
(28) All substances are made up of small particles called molecules which are alike in the same substance (except for variations in molecular weight due to isotopes) but different in different substances.	
What was Dalton's atomic theory?.....	j
Composition of molecules of elements.....	c
The battle over the molecule of Avogadro's.....	j
How Avogadro's hypothesis was actually verified.....	j
Why does the chemist believe matter is composed of molecules?	c
Evidences for molecules	c
Nature of molecules	c
Kinetic molecular theory	w
Atoms and molecules	w
Compounds contain different kinds of elements.....	a
(34) Elements and compounds to which the cells of living organisms react specifically, produce physiological effects.	
Enzymes	a
Grain alcohol, Enzymes	w
Enzymes and Hormones	w

TABLE II (CONTINUED)

Principle and Assigned Topics	Books
Sugars - Glucose from Starch	j
Animals cannot synthesize proteins	j
Alcohol	c
Carbohydrates	c
(44) All matter is composed of single elements or combinations of several elements and can be analyzed by chemical processes and divided into these constituents.	
How is a substance identified?	j
What is a compound?	j
The universe is made up of 92 natural elements	j
Definition of matter	a
How do we recognize matter?	a
Simplest kinds of matter, elements	a
Compounds contain different kinds of elements	a
When has a substance been changed?	a
Mixture and pure substance	a
Chemical Properties also aid in determination of the nature of a substance	a
Physical properties by which you can identify a substance	a
What are physical and chemical properties?	a
Primitive man and his knowledge of matter	w
The decline of alchemy	w
Elements	w
Compounds	w
Constant composition of Compounds	w
(58) Each combustible substance has a kindling temperature which varies with its condition but may be greater or less than kindling temperature of some other substance.	
Why some substances catch fire more easily than others	j
How to make a fire	w
Speed of oxidation	c
Oxygen reacts with substances to form oxides	a
(67) Metals may be arranged in an activity series according to their tendency to pass into ionic form by losing electrons.	
Hydrogen and activity series	j
Metals may be listed in the order of their replacement power	j
How the electron theory explains the replacement series	j
The replacement series of metals	w

TABLE II (CONTINUED)

Principle and Assigned Topics	Books
The replacement series of the metals is a useful tool	j
Why hydrogen is included in the replacement series of the metals	j
Two metal corrosion	w
Electrochemical series	w
The activity series of metals	c
Value of the activity series of metals	c
Displacement of one element in a compound by another	a
(76) Suspended particles of colloids have a continuous, erratic movement due to colloidal, molecular, or ion impacts.	
Characteristic properties of matter in the colloidal state .	j
The Brownian movement	c,j
Development of colloidal chemistry	c
(84) The solubility of solutes is affected by heat, pressure, and the nature of the solute and solvent.	
How to make a solution	w
How can we make things dissolve faster?.....	a
What determines the amount of solute that will dissolve? ...	j
What is a saturated solution?	j
Factors which affect solubility	c
Factors affecting the rate of solution	c
(86) A pure substance (Chemical) may be prepared from raw materials through utilization of their physical and chemical properties.	
Mixtures and pure substances	a
Terms used to describe purity	a
How is a substance identified?	j
How can you recognize matter?	a
What are physical and chemical properties?	a
Physical properties by which you may identify a substance...	a
Chemical properties also aids in the determination of the nature of the substance	a
What are the properties of matter?	w
Classification of matter according to composition	w
Physical states of matter	c
Chemical properties of matter	c
How does a chemist recognize and classify materials with which he works?	c

TABLE II (CONTINUED)

Principle and Assigned Topics	Books
(88) The speed of chemical reaction is increased by increasing the concentration of any of the reactants; and is decreased by decreasing the concentration of any of the reactants.	
What factors can be used to control the point of equilibrium?	j
Extent of chemical actions, Factors influencing extent	w
The control of chemical reactions	c
The law of mass action and equilibrium	j
(93) No chemical change occurs without an accompanying energy change.	
Can any form of energy produce a chemical change?	j
Two laws or one?	j
Energy can neither be created nor destroyed	j
What is the relation between heat of formation and chemical stability?	j
Energy changes accompanying chemical reactions	c
(Chemical reactions, reagents and equations) The control of chemical reactions.....	c
Starting chemical reactions	w
The law of conservation of energy	a
Chemical changes in energy changes	w
Matter and energy	w
(98) Elements are made up of small particles of matter called atoms which are alike in the same element (except for occasional differences in atomic weights; i.e., isotopes) but different in different elements.	
The origin of the idea of atoms	j
What was Dalton's atomic theory	j
How the kinetic theory of matter explains the liquification of air	j
The Atomic theory	w
Applications of the Atomic theory	w
Atoms and Molecules	w
Weight of an atom	w
Atoms and ions	c
The structure of matter	c
Evidence for atoms from a study of certain facts and laws ...	c
Dalton's atomic theory	c
Atoms - the smallest particles of elements	a
The size of atoms	a

TABLE II (CONTINUED)

Principle and Assigned Topics	Books
(107) Whenever the products of the concentration of any two ions in a mixture exceeds the value of the ion-product in a saturated solution of the compound formed by their union, this compound will be precipitated.	
The law of mass action and equilibrium	j
How the addition of a common ion forces a reaction to go to completion	j
Completed reversible chemical actions	w
Ionic equilibrium in solution	c
Extent of chemical actions	w
(108) Atoms of all elements are made up of protons, neutrons and electrons and differences between atoms of different elements are due to the number of protons and neutrons in the nucleus and to the configuration of electrons surrounding the nucleus.	
The hydrogen atom and the proton	w
What is the structure of the atom according to the electron theory?	j
The atom, a miniature solar system	j
How the structure of an atom may be represented graphically	j
What does the nucleus of the atom contain?	c
Structure of atoms	c
Diagraming the structure of atoms	[illegible],c
How does the electron theory explain the combining of atoms?	c
Atoms and ions	[illegible],c
Chemical activity and outer orbit electrons	c
What is the structure of an atom?	c,a
The interior of the atom	a
Atoms have a tendency to complete their outside orbit	a
How do atoms lose or secure electrons in order to have a completed outside orbit?	a
Why do elements have different valences?	a
Why do some atoms have a negative and some a positive valence?	a
The electron	w
Salts	w
(126) The properties of alloys are dependent upon the relative amount of their components, the extent of their compound formation, and upon the crystalline structure of the mixture.	
Nickel alloy, some alloys of iron and steel	j
Newcomers the light alloys of aluminum	j
Alloy mixtures	w
Steel alloys	c

TABLE II (CONTINUED)

Principle and Assigned Topics	Books
Metallurgy and chemistry	c
The nature and importance of alloys	c
The properties of alloys	c
Ferrous alloys	c
Nonferrous alloys	c
Mixtures	w
The age of alloys	w
Alloy steels	w
Theories of alloys	c
Metals have a positive valence	a
The properties of alloys	a
Other kinds of solutions	a
The alloy industry	a
What is an alloy?	a
How important are alloys?	a
Ferrous alloys	a
Non-ferrous alloys	a

(136) Electrolytes dissolved in water exist partially or completely as electrically charged particles called ions.

Ions and the importance of ionization	j
How Arrhenius explained the conductivity of solutions	j
How does an ion differ from an atom?	j
Where and how are free ions formed?	j
How the degree of dissociation was determined	j
How the theory of ionization fits in with electron theory.	j
How the theory of Arrhenius was later modified	j
What happens during the electrolysis of water?	j
What is hydrolysis?	j
What are reversible reactions?	j
When do reactions go to completion?	j
Atoms and Ions	c
Evidence for Ionic dissociation in solution	c
The theory of dissociation in solution	c
Chemical reactions in solution	c
Ionic equilibrium in solution	c
Reactions which do not result from equilibrium	c
Values of the theory of dissociation	c
Electrolysis of solutions	c
The theory of dissociation in the cell	c
The Ion	w
Distinction between an atom and an ion	w
Radicals form ions	w
Electron transfer	w

TABLE II (CONTINUED)

Principle and Assigned Topics	Books
Common Salt, an Ionic Lattice	w
How acids disassociate	w
Electricity in Chemistry	w
Strength of acids	w
Why do some atoms have a negative and some a positive valence?	a
Why was the theory of Ionization proposed?	a
Electrolytes and Non-electrolytes	a
Dilution increases Ionization	a
Further proof that ionization takes place	a
(138) Whenever the products of the concentration of any two ions in a mixture is less than the value of the ion product in a saturated solution of the compound formed by their union, this compound, if present in the solid form, will be dissolved.	
The law of mass action and equilibrium	j
How the addition of a common ion forces a reaction to go to completion	j
(143) Metals comprise the group of elements (other than hydrogen) whose atoms have a tendency to lose electrons readily and whose compounds when dissolved in polar solvents are capable of forming positive ions.	
Where and how are free ions formed?	j
How the electron theory explains metals and nonmetals.....	j
Arrangement of electrons	w
Properties of metals.....	c
Diagraming the structure of the atom?	c
Chemical activity and outer orbit electrons	c
Metals and non metals	c
Metallic oxides	c
What is the difference between a metal and a non metal? ...	a
Metals have a positive valence	a
(151) All chemical reactions which start with the same quantities of original substance liberate the same amounts of energy in reaching a given final state, irrespective of the process by which the final state is reached.	
Energy, too, can neither be created nor destroyed.....	j
Heat transformations that accompany changes in physical state.....	j
Two laws or one?	j

TABLE II (CONTINUED)

Principle and Assigned Topics	Books
Can any form of energy produce a chemical change?	c
Energy changes accompanying chemical reactions	c
Forces at work energy	c
How may man transform and use energy?	a
The law of the conservation of energy.....	a
Matter and energy	w
Changes in matter	w
Laws of conservation of mass energy	w
(155) Carbon atoms form a number of "type groups" of compounds which are determined by the structural combinations of the atoms within the molecules.	
How are the properties of hydrocarbon compounds explained by their molecular structures?	c
Hydrocarbons	c
The methane series	c
Methane	c
Structural formulas	c
Isomerism.....	c
Unsaturated hydrocarbons	c
Substitution products	c
Benzene series	c
Some substitution products of ring hydrocarbons	c
Other hydrocarbons	c
How can we apply the idea molecular structure to explain the classification and properties of hydrocarbon derivatives.....	w
Alcohols	w
Aldehydes, keotones and ethers	w
Formic aldehyde (formaldehyde)	w
Keotones, Ethers	w
Organic acids in general	w
Some important organic acids	w
Ethers	w
Soap	w
The methane series of compounds	j
What are hydrocarbons?	j
What are characteristics of the methane series?	a
Alcohol	j
(156) The boiling point of hydrocarbons increases with an increase in molecular weight.	
The methane series	c

TABLE II (CONTINUED)

Principle and Assigned Topics	Books
Methane	c
The methane series of compounds	j
What are the hydrocarbons	j
What are the characteristics of the methane series?	a
The importance of arrangement	w
(162) The heat of formation of any chemical compound equals its heat of decomposition.	
Energy changes accompanying chemical reactions	c
Energy, too, can neither be created nor destroyed	j
Can air be liquified?	j
How the kinetic theory of matter explains the liquification of air	j
Refrigeration	w
The refrigerator mechanism	a
Heat of formation	d
(165) Colloids have the property of adsorption to an unusual degree.	
Adsorption and the colloidal state	j
Activated charcoal	j
A black decolorizer	j
Properties of colloids	w
Charcoal	j
General properties of colloids	c
Chemistry of jellymaking	a
(166) The energy shown by atoms in completing their outer shell by adding, losing or sharing electrons determines their chemical activity.	
Completed shells	w
How the electron theory explains electric currents	j
How the electron theory explains chemical activity	j
Chemical activity and outer orbit electrons	c
How atoms join	w
Formation of molecules by the exchange of electrons	c
Metals and non-metals	c
Electrons and ionic valence	c
Atoms have a tendency to complete their outside orbit	a
How do atoms lose or secure electrons in order to have a completed outside orbit	a

TABLE II (CONTINUED)

Principle and Assigned Topics	Books
(180) Salts of strong acids and strong bases undergo negligible hydrolysis while salts of inactive acids and inactive bases undergo more marked hydrolysis.	
What is hydrolysis?	j
Hydrolysis	w
Hydrolysis reactions	c
The hydrolysis of salts	a
(182) Reactions occurring at ordinary temperatures are predominantly exothermic.	
Energy changes accompanying chemical reactions.....	c
What is the relation between heat of formation and chemical stability?	j
Heat of formation	w
Energy changes in chemical changes	w
(186) Enzymes, vitamins, and hormones are chemical regulators of the reactions that occur in living organisms.	
What do we eat and what should we eat?	j
Animals cannot synthesize proteins	j
What about vitamins?	j
The isolation and synthesis of the vitamins.....	j
Hormones and chemical control of body processes	j
Alcohols	c,j
Vitamins	c,a
Hormones	w
Enzymes	a,w
The use of vitamins in body	a
Vitamin A., B., complex G., C.	a
Some recently discovered vitamins	a
Hormones are chemical substances	a
Experimentation reveals new uses for hormones.....	a
(187) Surface reactions predominate in all non-homogenous reactions.	
A catalyst changes the speed of a chemical reaction.....	j
What factors can be used to control the point of equilibrium?	j
(188) The solubility of a gas in an inert solvent varies directly with the pressure to which the gas is subjected.	
What are the chemical properties of carbon dioxide?	j

TABLE II (CONTINUED)

Principle and Assigned Topics	Books
What are the physical properties of carbon dioxide?	j,c
How carbon dioxide is used in effervescent beverages.....	j
What determines the amount of solute that will dissolve?..	j
Correcting the gas volumes to standard conditions.....	j
Factors which affect solubility.....	c
Effect of pressure change	c
Solutions	w
(195) Most atoms have the properties of losing, gaining or sharing a number of outer shell electrons.	
Electronic theory	j
The atom, a miniature solar system	j
Structure of atoms	c
Diagraming the structure of atoms	c
Atoms have a tendency to complete their outside orbit.....	a
How do atoms lose or secure electrons in order to have a completed outside orbit?	a
Why do some atoms have a negative and some a positive valence?.....	a
Chemical activity and outer orbit electrons	c
Arrangement of electrons	w
How does the electrical theory explain the combining of atoms?	c
(197) The rates of many reactions are affected by the presence of substances which do not enter into the completed chemical reactions.	
How the speed of this reaction can be increased.....	j
A catalyst changes the speed of a chemical reaction	j
Bergius process	j
Chromium plating	j
Cracking petroleum	j
Formation of wood alcohol	j
Hydrolysis of starch	j
In leavening	j
In making rubber	j
In paint making	j
Catalysis in photosynthesis	j
Catalyst and adsorption	c
Adsorption and the colloidal state	c
The rate of burning; effect of catalyst.....	w
Oxygen for sale	w
Preparation of oxygen	a

TABLE II (CONTINUED)

Principle and Assigned Topics	Books
(201) Every chemical element when heated to incandescence in a gaseous state has a characteristic glow and characteristic spectrum which can be used to identify very small quantities of the element and which is related to the molecular and atomic structure of the gas.	
The principle of the spectroscope	j
How is a spectroscope used?	j
Analysis for the metals	c
What is the nature of light?	j
(203) In any and every sample of a compound formed, the proportions by weights of the constituent elements is always the same as long as the isotopic composition of each element is the same.	
The law of definite proportions	j
The law of definite composition	a,c
The law of constant composition	w
(204) The valence of an atom is determined by the number of electrons it gains, loses, or shares in chemical reactions.	
How the electron theory explains valence	j
How the electron theory explains chemical union and affinity	j
How the electron theory aids in balancing equations	j
How atoms join	w
What does the nucleus of the atom contain?	w
How does the electrical theory explain the combining of atoms?	c
Formation of compounds by the sharing of electrons; covalence	w
Atoms have a tendency to complete their outside orbit	a
Why do elements have a different valence?	a
(210) The total mass of a quantity of matter is not altered by any chemical changes occuring among the materials composing it.	
Law of the conservation of matter	c
Matter can neither be created nor destroyed	j,w
Can man create matter?	a
(211) The properties of the element show periodic variations with their atomic number.	
Atomic numbers	c
Moseley discovers the laws of atomic numbers	j

TABLE II (CONTINUED)

Principle and Assigned Topics	Books
The periodic table of Mendeleyeff.....	j
The table of atomic numbers is fundamental.....	j
Later progress in periodic grouping.....	w
The periodic table.....	a appendix
(213) A few elements are inert or chemically inactive because their atoms are so constructed as to be complete in themselves, i.e. their outer electron rings have no tendency to gain or lose electrons.	
How the electron theory explains chemical activity.....	j
How does the electron theory explain chemical union and affinity.....	j
Chemical activity and outer orbit electrons.....	c
Completed shell.....	w
Atoms have a tendency to complete their outside orbit.....	a
(215) The electrons within an atom form shells about the nucleus, each of which contains a definite number of electrons.	
How the structure of an atom may be represented graphically.	j
What does the nucleus of the atom contain?.....	j
Diagraming the structure of the atoms.....	c
Structure of atoms.....	c
The interior of the atom.....	a
Arrangement of electrons.....	w
(216) Orderly arrangement of molecules, atoms, or ions in crystals give crystals regular form.	
What is the water of crystallization?.....	j
What are the allotropic forms of sulfur?.....	j
How x-rays may be used in determining the crystal structure.	j
Crystals of commerce.....	w
Solids.....	w
Formation and characteristics of crystals.....	c
Crystals and their fashions.....	c
Crystalline and amorphous substances.....	a
(217) Elements may be changed into other elements.	
Ancient and modern alchemy.....	j
Element No. 93.....	j
The key to modern atomic energy	j

TABLE II (CONTINUED)

Principle and Assigned Topics	Books
An element changes	w
The transmutation of elements	w
Radioactivity and atomic structure	c
Natural radioactivity	a
(225) The gravimetric composition of a compound may be found by multiplying the atomic weights of the elements by their subscripts in the formula of the compound.	
What is the purpose of subscripts in formulas?	j
How to find the molecular weight of a compound from its formula?	j
Solving type problems in chemistry	j
Calculating relative weights of atoms and molecules	c
Formulas and their meaning	j
Chemical formulas	j
How to derive formula weights from formulas	w
The molecular weight of a compound	a
(232) Unsaturated hydrocarbons are active chemically and form many compounds by addition.	
What are hydrocarbons?	j
Methane and its substitution products	j
The methane series of compounds	j
Series of compounds hydrocarbons	w
Organic radicals	w
Carbon to carbon to carbon	w
Saturated and unsaturated compounds	w
Hydrocarbons	c
The methane series	c
Structural formulas	c
Unsaturated hydrocarbons. Substitution products	c
What are hydrocarbons?	a
What derivatives or substitutions products of methane are possible?	a
(233) Temperature changes, pressure changes, the presence of electrolytes or the presence of oppositely charged particles may cause colloids to precipitate.	
How colloids are precipitated	j
How colloids may be kept from precipitating	j
Acids and alkalies also precipitate colloids	j

TABLE II (CONTINUED)

Principle and Assigned Topics	Books
Common dispersed systems	c
General properties of colloids	c
Stabilizing colloidal dispersions	c
Properties of colloids	w
How colloids are made	w
Causing colloidal particles to come together	w
Causing colloidal particles to stay suspended	c
The chemistry of jelly-making	a
(234) The ingredients of a solution are homogeneously distributed through each other.	
What is a solution?	j
Solution - definition in glossary	w
Characteristics of solutions	c
What is a solution? Solvent, solute and solutions	a
(240) Colloidal particles may carry electrical charges.	
Characteristic properties of matter in the colloidal state	j
How colloids are precipitated	j
Properties of colloids	w
Causing colloid particles to stay suspended	w
General properties of colloids	c
Common dispersed systems	c
(241) Colloids show greater chemical activity than the solid substances in mass, since rates of reaction are proportional to the surface area of the solid, other factors being equal.	
Characteristics - properties of matter in the colloidal state	j
Properties of colloids	w
Causing colloid particles to stay suspended	w
General properties of colloids	c
Common dispersed systems	c
Adsorption and the colloidal state	j
How colloids are made	w
(245) Each element has its own characteristic x-ray spectrum.	
Moseley discovers the law of atomic numbers	j
How x-rays may be used in determining crystals structure	j
Later progress in periodic grouping	w
Applications of the theory of atomic structure	c

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TABLE II (CONTINUED)

Principle and Assigned Topics	Books
(248) When a chemical change takes place without the addition of heat from an external source, that substance which has the greatest heat of formation will tend to form.	
What is the relation between the heat of formation and chemical stability?	j
Starting chemical reactions	w
Heat of formation	c
(249) When different amounts of one element are found in combination with a fixed weight of another element (in a series of compounds) the different weights of the first element are related to each other by ratios which may be expressed by small whole numbers.	
Daltons discovers the law of multiple proportions	j
How the discovery of a new compound helped to uphold the law of multiple proportions	j
Applications of the atomic theory	w
Evidences for atoms from a study of certain facts and laws. Laws of definite composition; law of multiple proportions.	c
The technique of formula writing	a
(252) The specific heats of many elements are approximately inversely proportional to their atomic weights.	
How the atomic weight of an element may be determined experimentally when the element does not exist in gaseous compounds. Law of Dulong and Petit	j
(253) Non-metals comprise a group of elements whose atoms tend to gain or share electrons and whose compounds, when dissolved in polar solvents, are capable of forming negative ions.	
How the electron theory explains metals and non-metals	j
How the theory of ionization fits with the electron theory	j
The replacement of the nonmetals	j
Elements. Nonmetal and metals	w
How atoms join electro valence	w
Chemical elements	c
Metals and nonmetals	c
Electrolytes from the standpoint of ionization	c
Non-metals have a negative valence	a
Electrolytes and non-electrolytes	a

TABLE II (CONTINUED)

Principle and Assigned Topics	Books
(255) Alcohols react with acids to form esters and ethers.	
Esters include fragrant oil of cloves and explosive nitro-glycerine	j
Organic "neutralization"	w
Ethers	w,c
Esters	w,c
How are esters formed?	a
What derivatives or substitution products of methane are possible?	w
Fats and oils also constitute part of our diet	j
(256) Simple ionic reactions are typically rapid reactions.	
Where and how are free ions formed?	j
Arrhenius Theory	j
Chemical reaction in solution	c
Electrolytes and non-electrolytes	a
The theory of dissociation in solution	c
Strength of acids	w
How acids dissociate	w
(258) If stress is applied to a reversible chemical system there will be a readjustment in the system to relieve the stress.	
What factors can be used to control the point of equilibrium?	j
What are reversible reactions?	j
Reversible reactions and equilibrium	j
Reactions which do not result in equilibrium	c
Extent of chemical actions	w
Reversible chemical actions	w
Completed reversible chemical actions	w
Ammonium hydroxide	a
(259) Chemical reactions may be carried more nearly to completion by any condition that establishes an unusually low concentration of one of the products.	
The law of mass action and equilibrium	j
How the addition of a common ion forces a reaction to go to completion	j
Extent of chemical actions	w
Completed reversible chemical actions	w

TABLE II (CONTINUED)

Principle and Assigned Topics	Books
(260) Any substance soluble in two immiscible liquids will distribute itself between the two in proportion to its solubility in the two liquids.	
(262) At a definite temperature and pressure, the relative combining volumes of gases and of gaseous products may be expressed approximately in small whole numbers.	
Composition of molecules of elements.....	c
Guy-Lussac finds the law of combining volumes of gases.....	j
Is the sum of 2 and 1 always 3?.....	j
The law of combining volumes - Guy-Lussac's law.....	a
(263) Molecules of some compounds undergo polymerization.	
The composition and treatment of gasoline.....	j
Sources of rubber, another hydrocarbon	j
A few important plastics	j
Nitrogen Tetroxide	w
Polymer gasoline	w
Artificial rubber from petroleum	c
Cracking gasoline	a
The chemistry of plastics	a
(266) The products of reacting substances may react with each other to form the original substances.	
What factors can be used to control the point of equilibrium?	j
What are reversible reactions?	j
Reversible reactions and equilibrium	j
When do reactions go to completion?	j
Reactions which do not result in equilibrium	c
Reversible chemical actions	w
Ammonium hydroxide	a
(267) Equal volumes of all gases under similar conditions of temperature and pressure contain very nearly the same number of molecules.	
Avogadro continues his work with gases.....	j
Of what value to chemistry was Avogadro's hypothesis.....	j
How Avogadro's hypothesis was actually verified.....	j
Avogadro's law	a
Avogadro's reasoning	w
Chemical geometry	w

TABLE II (CONTINUED)

Principle and Assigned Topics	Books
Directions for solving straight volume problems.....	c
Composition of molecules of elements	c
(268) Equal amounts of heat raise equal numbers of atoms of all elements in the solid state through nearly equal intervals of temperature.	
(269) Non-metals may be arranged in an activity series according to their tendency to pass into ionic form by gaining electrons.	
The replacement series of nonmetals.....	j
An element is known by the company it keeps	j
How the electron theory explains metals and nonmetals	j
Replacement of negative ions	w
Behavior of halogen elements with halogen compounds	c
Metals and non-metals	c
Nonmetals have a negative valence	a
Displacement of halogens	a
(270) In a saturated solution the product of the molar concentration of the ions is constant.	
The law of mass action and equilibrium	j
How the addition of a common ion forces a reaction to go to completion	j
(271) Saturated hydrocarbons are relatively inactive chemically but form compounds by substitution.	
Methane, and its substitution products	j
The methane series of compounds	j
What are hydrocarbons?	a
What are the characteristics of the methane series?	a
What derivatives of substitution products of methane are possible?	a
Substitution products	c
Saturated and unsaturated hydrocarbons	w
(272) Alcohols oxidize to aldehydes, ketones, and acids.	
What is an alcohol?	j
Acetones, ether, and formaldehyde.....	j
Acetic acid, the most commonly used organic acids	j
Other common organic acids	j

TABLE II (CONTINUED)

Principle and Assigned Topics	Books
Other organic groups	w
Helpful comparisons	w
Alcohols	c
Aldehydes, keotones, and ethers	c
Organic acids	c,e

FINDINGS, TABLE II

With the exception of two principles*, each was found to be developed by the textbooks under various topics. It was found that 548 topics could be assigned to the sixty-six principles of chemistry from Blanchet's study. In Jaffe's book, 183 topics were found to be developing principles: Weaver and Forster had 120 topics devoted to this task; Kruh-Carpenter contained 139 topics suitable for teaching principles; and Ahrens-Bush book showed 106 topics.

The two principles not found in the books seemed to be too technical for the average high school class and were probably suitable for Junior College only. Jaffe's book not only had the most complete sections devoted to the development of principles, but also had the most descriptive chemistry as well. The Ahrens-Bush's book did not devot much space to many of the principles as most of the other books, but had several good illustrations of principles actually being used. The Weaver and Forster book concentrated on fewer principles which were usually well developed. In Kruh-Carpenter, most of the principles were found but little space was given to several important principles such as the electron theory and chemical reactions.

*(268) Equal amount of heat raises equal numbers of atoms of all elements in the solid state through nearly equal intervals of temperature.

(260) Any substance soluble in two immiscible liquids will distribute itself between the two in proportion to its solubility in the two liquids.

CHAPTER III

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

RESTATEMENT OF THE PROBLEM

This study was undertaken to find out the number of topics that four of the latest chemistry textbooks devoted to the developing of an understanding of validated principles of chemistry. From this study it is hoped that the classroom teacher might be able to select a textbook that conforms to the recommendations of the Thirty-first[29] and Forty-sixth Yearbooks[30] insofar as the teaching of principles is concerned.

SUMMARY OF THE TECHNIQUES EMPLOYED

A composite outline of topics found in each of the four secondary chemistry textbooks was formulated and the defensibility of the position of each topic in the outline was approved by three experienced chemistry teachers. The number of topics devoted to the understanding of each principle of chemistry as assigned by Blanchet from the Harold E. Wise study was then checked and stated the topic under the appropriate principle. The validity was ascertained by submitting the list of assignment of different topics to principles of chemistry to three experienced chemistry teachers.

SUMMARY OF THE FINDINGS

Of the defensible assignment of the topics to the principles of chemistry, 183 were found in book j; 139 were found in book c; 120 were found in book w; 106 were found in book a. Thus different assignments of topics found in a majority of the four textbooks were assigned to sixty-six

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[29]Thirty-first Yearbook, Op. cit., P. 44
[30]Forty-sixth Yearbook, Op. cit., P. 31

different principles. Complete totals show 548 different assignments of topics to the four textbooks. Most of the books had similar topics although organized along different units and major topics.

CONCLUSIONS

Results of the study indicate a wide range in the number and nature of chemistry principles found in each of the four textbooks. In general, it may be said there is room for great improvement in the organization of the latest textbooks in terms of the development of principles rather than in terms of merely descriptive chemistry and isolated facts. It is felt that more space than is now given to the development of principles, even at the expense of descriptive chemistry is necessary if teachers are to be able to use these books effectively in the teaching of the functional understanding of principles.

In the analysis of the textbooks, it is found that there is little uniformity in the selection of major topics by the authors of the different textbooks although each has the topics demanded by college entrance requirements. Again the great percentage of space devoted to descriptive chemistry must be challenged if it does not aid in the development of the understanding of principles. If the latest textbooks have not as yet been organized in terms of the understanding of principles to be secured rather than mere facts, then there is little opportunity for the classroom teacher to set up his work with this organization in mind.

SUGGESTIONS FOR APPLICATION OF FINDINGS AND FOR FURTHER STUDIES

An analysis of the findings leads to the following recommendations:

(1) A new series of textbooks should be written based upon an

organization around the development of principles.

(2) Further work be undertaken on the listing of practical illustrations of validated principles.

(3) The program of studies should be organized around the developing of validated principles rather than around descriptive chemistry.

(4) The principles already developed should be assigned to different grade levels as a result of further studies.

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